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UNITED STATES
NAVAL POSTGRADUATE SCHOOL

DEPARTMENT OF AERONAUTICS

TECHNICAL NOTE
NO.

OPERATIONAL PROCEDURES

FOR THE

TURBOJET ENGINE LABORATORY

WITH J-57-8B ENGINE

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UNITED STATES NAVAL POSTGRADUATE SCHOOL
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PREPARED BY: ______________________ __________

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APPROVED BY: ______________________ __________

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OPERATIONAL PROCEDURES FOR THE TURBOJET ENGINE TEST FACILITY WITH THE J-57-8B ENGINE

1. Purpose:

This note is intended to acquaint all student and staff personnel of the required procedures for safe operation of the subject powerplant and each sub-system in the test facility. This summary will be revised periodically to reflect any changes in engine configuration and any modifications to the facility instrumentation system. Although it is intended that the data contained herein shall be sufficient to enable any authorized personnel to operate each of the facility sub-systems, as well as the J-57-8B engine, it is requested that all tests be conducted with the aid of qualified staff technicians. Actual operation of the J-57 engine should be performed by designated Technicians trained in Jet engine testing.

2. Pre Test Familiarization:

The material presented below should be review by the testing personnel prior to the operation of any sub-system. A "walk-through" of the complete test sequence should be conducted with the help of qualified staff technicians.

2.1 Cooling Tower and Water Supply System: The purpose of the cooling water system is to cool the mechanical equipment in the Jet Engine Test Facility and the Compressor Laboratory. The cooling tower is located South of the turbojet chamber and adjacent to the compressor lab. Water flows from the cooling tower to the equipment room at the rear of the test facility and cools the following units; (a) the jacket and inter-cooler of the low pressure compressor (Penn), (b) the after-cooler for the low pressure system, (c) the waterjacket and the first and second stage inter-coolers for the high pressure compressor (Worthington), and (d) the lubeoil heat exchanger for the engine lubrication systems in the turboject and turboprop cells.

The cooling tower pump must be ON before the above compressors are operated and must remain ON until after these units are shut-down. The pump is started by closing the circuit breaker and pushing the Water Tower Pump Switch

on the power panel in Room 109 of the Compressor Laboratory. Water will immediately flow through the lube oil heat exchanger but solenoid valves prevent the flow from entering both compressors until after they have been energized. The Cooling Tower Fan Switch should not be utilized since the additional cooling capacity with the fans operating is required only for equipment in the Compressor Laboratory.

At each compressor there is a gate valve in the cooling water supply line and in the return line. These valves should remain fully open at all times.

In the water return line from each compressor, there is a sight-glass for observing the water flow. The water should be continually inspected for clarity. The cooling water becomes dark red in color due to the algae in the semi-closed system, and the impellor inside of the sight-glass cannot be seen. When this condition develops, the cooling tower system should be drained and flushed.

2.2 Low Pressure Compressor: This unit furnishes air at controlled pressures up to 150 psia and 700 scfm, and temperatures up to 1000°F for engine starting, for the utility shop air lines and for the instrumentation system. The Penn compressor is located at the East end of the equipment room and supplies air to the above systems in the turbojet cell, the turboprop cell and the control room. In addition, utility shop air is furnished to the Compressor Laboratory and to the Cascade Laboratory and Maintenance Building. Due to the use of air operated valves in other sub-systems, it is recommended that the compressor and the cooling water pump be started approximately 30 minutes before the initiation of any test sequence.

After insuring that the cooling tower pump is operating, the Penn compressor may be started as follows:

The main circuit preaker on the power panel along the North wall of the equipment room should be ON. Air Dryer Switch should be turned ON. The remaining steps for starting and controlling the compressor can be

accomplished at the Control Panel on the front of the compressor.

The Start - Run Selector Switch must be placed in the Start position.

Press the black Start Button and hold until the oil pressure gauge indicates 30 PSI.

Release the Start Button, allowing the compressor to operate in the unloaded condition while listening for unusual noises and checking the lubricator sight glasses for proper feed of oil to the cylinders.

Check the cooling water sight-gauge for flow indication. The rotating impellor will spin as the water passes through the system. Should there be no indication of cooling water flow, then immediately shut down the compressor and take corrective action to restore the flow of water.

After allowing the compressor to operate for one minute in this unloaded condition, turn the Selector Switch to the Run position.

The compressor will immediately start compressing and will run fully loaded until the pressure has reached approximately 143 PSI as indicated on the Discharge Pressure Gauge. The automatic unloader will then engage and reduce the compressing process. If the demand upon the air supply is moderate, the discharge pressure will continue to rise to 150 PSI or slightly higher. The second unloader will then engage and the compressor will run unloaded at the idle setting. The loading and unloading cycle will continue automatically to satisfy the requirements imposed upon the air supply system. During this operation the cooling water temperature should be periodically checked so as to not exceed 90^{o}F.

To stop the compressor it is necessary to depress the red Stop button all the way in to the seat, and then release it. If the Stop button is only partially depressed, the compressor will stop, but the electrical interlock between the unloader solenoid and the oil pressure switch will not be energized. This may lead to difficulty when a start is attempted.

2.3 Low Pressure Air Heater: When the high temperature supply system is required for starting certain gas turbine engines, the Polytherm Air Heater must be utilized. (The J-57 engine presently installed in the cell requires 400^{o}F air flow for starting.) This heating unit, located outside the East wall of the equipment room, adjacent to the low pressure air receiver, is capable of yielding 1.75 PPS airflow at 150 psia and 1000^{o}F. Operation of

this system could be hazardous if the following instructions are not explicitly followed. It is desirable that the operator be completely familiar with the over-all air supply system to insure that proper valving sequences are maintained. This knowledge should minimize any chance of equipment malfunction and should reduce the time lost if trouble-shooting becomes necessary.

The heater must NEVER be operated without an adequate airflow through the heating tube elements. Before starting the heater, the chain operated vent valve which allows the air stored in the receiver to flow overboard to the atmosphere should be slightly opened. This will permit adequate venting of oil vapors that have filtered through and collected in the heating elements. This chain valve can be closed only if the vent valve in the test chamber is slightly open or if the engine is being started.

To start the heater the two circuit breakers, marked Air Heater and Air Dryer, on the power panel in the equipment room should be closed. At the outside of the building the main gas line can be opened.

The control console attached to the heater should be unlocked and the two circuit breakers adjacent to the Thermocouple Selector Switch should be closed, as should the Blower Circuit Breaker in the lower right hand corner. The instrument air supply pressure should be checked, and reset if required, to 20 PSI. The Protectovàn Control button can now be depressed. The red light on the Protectogolo Panel should come ON.

After approximately five minutes, the red light will go out and the green light will come ON. The Start Button can now be depressed to ignite the pilot light. Check the pilot light through the inspection port and, if ignited, move the Temperature Control Knob to the Manual position and OPEN the Manual Reset Gas Valve adjacent to the Control Panel. Now move the Temperature Control Knob back to Automatic and the heater main burner will ignite.

Set the Temperature Control to the desired temperature for proper engine start conditions. The heater will raise the temperature to the desired limits within approximately two (2) minutes. The heater will then retard to "low" flame and hold this specified temperature under moderate airflow requirements.

To shut the heater off- depress the STOP button, open the two circuit breakers, and turn off the Blower circuit breaker switch. Close the gas supply valve and open the circuit breakers on the power panel in the equipment room.

NOTE: Continue to operate the compressor, and OPEN the chain operated vent valve to facilitate the rapid cooling of the heater elements.

One precautionary measure should be observed; when checking the various heating element temperatures, it is necessary to switch from one thermocouple to another. During this switching, always depress and hold the T/C Switch Button. If the button is not held in this position, then the heater will receive a false over-limit signal and will automatically shut-down.

2.4 <u>Low Pressure Air Supply Ducting</u>: After starting the low pressure air compressor and the air heater, the air supply ducting should be checked to insure the proper flow to the desired outlet in the test chambers. The cold air supply line and the hot air duct returning from the reservior outside of the building can be traced along the South wall of the equipment room. If only a cold air supply of air is required for starting, do not re-adjust the Temperature Controller (TC-1) which directs the two mixing valves. (TCV-1A and TCV-1B). Although these valves will open, no flow will pass through the hot air duct. The adjusting mechanism is located inside of the Temperature Controller and the front cover plate must be removed.

If the heater is utilized for "hot starting" then this same adjusting unit in the Temperature Controller should be set at the desired temperature. The aforementioned mixing valves will then automatically adjust to yield the desired valve.

The pressure regulation of this air supply system is accomplished by the Pressure Regulating Valve, (PCV-2), which is located directly below the Temperature Controller. The desired pressure can be obtained by opening the front cover plate of the unit and setting the pressure scale.

The outlet pressure and temperature at this point in the supply system can be observed from the gauges located immediately downstream of the Pressure Regulator. The insulated vertical duct adjucent to the Pressure Regulator supplies air to the Turboprop Chamber while the next duct furnishes air to the Turbojet Cell.

In each of the test chambers the air supply duct passes through two valves which are connected in parallel. One valve is a chain operated venting unit to insure continual flow through the system when not being utilized for a test program. This valve <u>must</u> remain open at all times, <u>if</u> the vent valve at the heater outlet is not opened. The other valve is only opened during engine starting and is actuated by the Engine Start Button on the console in the control room. During an engine start the valve is closed manually by the Starter Cutout Switch or automatically by the turbojet engine starter. In order to prolong the life of the engine's starter unit, it is recommended that the airvalve be closed manually.

3. <u>Fuel Supply System</u>. JP-4 or JP-5 fuel is stored in two 10,000 gallon underground storage tanks located Northeast of the engine test chamber. The fuel pump at each tank will deliver up to 50,000 pounds per hour to the filtering and metering area adjacent to the facility rear wall. The fuel is filtered, measured for density and pressure, and then passes through either the high or low range fuel flow transmitter before entering the test cell. A fuel flow totalizer is also installed which measures the fuel quantity used during the test sequence. The fuel line passes along the roof of the equipment room and enters the chamber at the rear wall. The line terminates at the quick-disconnect fitting located adjacent to the instrumentation panel. A flexible hose is used to connect the fuel line to the engine fuel control.

The operation of the fuel supply system is as follows;

The Fuel Pump Circuit Breaker in the Equipment Room should be "ON". Electrical power, 115 VAC and 24VDC, must be available to the engine control console in the Control Room. See the Electrical System Section for further circuit details.

To prevent malfunction of the system due to interlock features in the electrical system, the Engine Master Switch and the Water Interlock Switch must be "ON".

Depressing the Fuel Tank Start Switch (Each pump has a separate switch), will start the fuel pump and open the fuel valve at the pump outlet. Fuel should flow from the storage area to the filter and metering area and into

the test chamber. The fuel will terminate at the air-operated gate valve which is controlled by the Fuel-to-Engine Switch during engine starting.

CAUTION: Always insure that the hand operated valve immediately upstream of the fuel filter is "OPEN" and that the return line valve adjacent to the fuel totalizer is "CLOSED". (Unless recirculation is desired). If there is any possibility that the fuel lines contain trapped air, due to system modification or to a depleted fuel supply, then the valve upstream of the filter should be CLOSED and the return line valve should be OPENED before starting the pumps. With the pumps operating, slowly open the closed valve PARTIALLY and allow the reduced fuel flow to circulate for five minutes. This action should purge the system of trapped air and reduce the possibility of damage to the fuel flow transmitter impellors due to fluid impact forces.

Fuel to the engine is available by the Fuel-to-Engine Switch. This switch will be actuated just prior to the engine start. The throttle should always be locked in the "OFF" position unless an engine start is in process.

Emergency Shut-down can be accomplished by depressing the Fuel Pump Stop button or by closing the Fuel-to-Engine switch. It should be noted that the Cardox fire protection system is coupled to the electric gate valve at the fuel pump and will close this unit automatically if fire occurs.

The fuel line in the test chamber contains a pneumatic reservior which serves to cushion the fuel system against hydraulic shock if the fuel is shut off abruptly during high flow rates, i.e., emergency shutdown during Military power operation and above. Such loads imposed upon the copper fuel lines without this accumulator could rupture any segment of the system with hazardous results.

A Low Fuel Pressure Warning Light is provided on the control console. If the light comes "ON" during operation, switch immediately to the other fuel tank and check for continued pressure drop. This switching should not cause any interruption in the fuel flow and will not effect engine operation.

Each of the fuel tanks contains a long riser pipe on the top of which is mounted a combination vacuum breaker and a pressure relief valve. In event that the vapor pressure should cause the relief valve to OPEN and admit vapor to the atmospher and this gas should ignite, then the chain on the pipe must be pulled to close the valve. This should snuff out the flame.

4. Faculity Electrical System. The electrical power available in the test facility is 115/230v-60 cycle, 115v-400 cycle and 28 VDC. Two motor-generator units located in the equipment room furnish the 115v-400 cycle power and the 28 VDC power while a rectifier in the control room delivers an additional 28 VDC at 1000 amps for engine starting units. Note that the 1000 amp rectifier has a potential of abour 78 volts DC when not loaded.

The circuit breakers for the two M-G sets are located in the Southeast corner of the control room. The M-G units are started by switches on the power panel in the Equipment Room. The power characteristics of these units can be observed by instruments located on the control console.

If the rectifier is to be used for engine starting, the Engine Start Selector Switch on the control console should be set at "Rectifier". Starting power will be available only when the Engine Start button is depressed. The rectifier unit is operated by a Start and Stop switch on the front panel of the rectifier.

CAUTION: A three-way switch box located adjacent to the front door of the control room supplies electrical power to either of the control consoles-but NOT to both at the same time. Insure that the switch is CLOSED for the control console being utilized. The switch should be in the middle position when the facility is unattended.

The function of the facility components will be discussed more fully in the Pre-start, Start and Engine Operation Sections. However, the following table briefly identifies the circuits that are required for operation of each sub-system.

Facility Sub-system	Electrical Unit	Location
Low Pressure Air Supply	Cooling Tower Pump Switch	Compr. Bldg.
	Cooling Tower Pump Circuit Br'kr	Compr. Bldg.
	Cooling Tower Water Circuit Br'kr	Equip. Rm.
Low Pressure Air Heater	Cooling Tower Pump Switch	Compr. Bldg.
	Cooling Tower Pump Circuit Br'kr	Compr. Bldg.
	Cooling Tower Water Circuit Br'kr	Equip. Rm.
	Air Dryer Circuit Breaker	Equip. Rm.
	Air Heater Circuit Breaker	Equip. Rm.
Control Console & Instrumentation	Console Control Box	Control Rm.
	J-Box, Sw. Nos. 14, 16, 18	Control Rm.
	28 VDC M-G Circuit Breaker	Control Rm.
	115 VAC M-G Circuit Breaker	Control Rm.
	Engine Master Switch	Console
	120 VAC Switch	Console
	Water-Interlock Switch	Console
Exhaust Water	Exhaust Water Circ. Br'kr	Equip. Rm.
	Control Console (See above)	Control Rm.
Fuel Supply	Fuel Pump Circuit Br'kr	Equip. Rm.
	28 VDC M-G Circuit Breaker	Control Rm.
	Control Console (See above)	Control Rm.

5. Exhaust Water System. The exhaust augmenter water system is designed to cool the engine exhaust passages to below 400°F. The water is stored in a 5000 gallon tank located outside of the test chamber North wall and is pumped into the circular spray ring assembly mounted in the front plane of the exhaust augmenter tube. A thermo-switch mounted in the exhaust passage is set to trigger a klaxon and a warning light on the control console if over-limit temperatures are induced.

CAUTION: Water flow is NOT automatic and must be turned ON and OFF by using the Exhaust Water Pump Switch on the console. Exhaust passage temperatures should be continually monitored during engine operation at Military power and while in the afterburning range.

To operate the system it is necessary to CLOSE the Augmenter Water Circuit Breaker in the equipment room. Electrical power must be available to the control console. See the Facility Electrical System Section for details.

At the supply tank check the water level and insure the reservior is full before starting the engine. OPEN FULLY the valve at the tank outlet. PARTIALLY OPEN the gate valve at the downstream side of the pump. (See the Engine Pre-start Section for the proper setting for the type of engine being tested.)

The Exhaust Water Pump Switch on the console controls the flow to the spray rings. The water should be turned ON just prior to advancing the engine to the desired power setting and should remain ON until after retarding to a lower power level which requires no cooling water. Unless emergency conditions prevail, do NOT shut down the engine immediately after closing the exhaust water system, but operate the engine for at least three minutes to remove the excess water in the passages. Water trapped in the acoustic panel will lead to deterioration of the sound suppression system.

If maximum water flow rates are utilized for adequate cooling at high power settings, the water supply in the tank should be closely monitored. The pump will deplete the tank supply in approximately fifteen minutes of continual operation. With the valve partially open continual operating times of thirty minutes should be available.

6. Instrumentation/Control Systems.

6.1 Starting & Ignition: The controls for selecting and operating the electrical or pneumatic starting systems in the test facility are located on the control console. The prime sources are; the 24 VDC from the rectifier, the low pressure (150 PSI) air supply from the Penn compressor, the high pressure (1000 PSI) air system from the Worthington compressor and the emergency electrical power from a start-cart when one is located outside of the test chamber.

The Start Selector Switch should be positioned for the type of starting desired. If "air starting" is required, high or low pressure, the Selector Switch will apply electrical power to the air solenoid valve in the proper air supply line when the Engine Start Switch is energized. The solenoid will close by actuating the Starter Cut-out Switch or by the action of the starter's centrifugal switches.

When electrical starting is required, the Selector Switch will connect the Contactor to the rectifier or to the outside power cart. The Engine Start Switch and the Starter Cut-out Switch control the start process as described above. The Contactor for the rectifier is located in the connector panel in the test cell while the unit for the emergency power cart is mounted on the North wall of the test chamber.

The ignition system may be checked by placing the Ignition Test Switch in the "Test" position and noting the firing of the ignition units on the engine. When engine "motoring" without the ignition is desired, select the type of starting power necessary and OPEN the Ignition Cut-out Switch and depress the Engine Start Switch.

If the starter on the engine does not have centrifugal switches, or if their use is not desired, a jumper-plug must be installed on the Start Valve Connector located on the Engine Connector Panel. If centrifugal switches are to be utilized, they must be wired in series with the subject connectors.

6.2 Fuel Flow Indication: The Fuel Supply System has been described in a

previous section, however once the supply system is activated for engine operation, the indicating units described below began to function.

On the control console are; a low-pressure warning light, two pressure gauges and a flow indicator.

The Low Fuel Pressure Warning Light should normally be OFF during engine operation, indicating an adequate pump pressure and a sufficient fuel supply. Should the light come ON while operating the engine, observe and record the pressures indicated on the two fuel gauges on the console and shut down the engine. The two pressure gauges reveal the Fuel Boost Pressure and the Engine Fuel Control Outlet Pressure.

Volumetric flow is sensed by signal turbines installed in the lines at the filter area. The signals are transmitted to a flow indicator on the control console. There are two turbines in the system and yield high flow rates and low flow values. The indicator when set at "Automatic" will detect and select the proper flow turbine. Do NOT set the indicator on "Low Flow" if the engine tested can consume more than 5000 PPH, as inadvertant fuel starvation and flame-out may occur. True mass flow will be displayed on the indicator, in pounds per hour, if the Specific Gravity Adjustment is set at "Auto" or by placing the switch in "Manual" and setting in the correct specific gravity on the Specific Gravity Dial. The specific gravity of the fuel being used can be indicated on the flow indicator, since a density transducer is located in the system at the filter outlet. By setting the Function Selector Knob at "Sp. Gr.", the actual specific gravity can be observed on the display window.

6.3 <u>Engine Support/Thrust Measuring System</u>: The engine is mounted on a support bed similar to the Navy Standard CVA Test Stand Assembly presently utilized in Class "C" Test Cells and onboard "CVA" aircraft carriers. The engine mounts are standard stock items from the Aviation Supply Office. The support bed rests upon a "floating" frame that is attached to eight foot vertical columns at each corner through the use of thin "flexure" plates. The flexure design is similar to that utilized at the Naval Air Turbine Test Station. With such a design only a very small horizontal force is required to move the floating assembly which rides against the

thrust load cell. The load cell is positioned in the vertical plane of the engine and is mounted on the base of the front support columns. During engine operation, the forward movement of the assembly applies a compressive force to the load cell. This load is transmitted to the indicator on the control console and indicates directly the thrust of the engine.

A calibration load cell can be installed at the rear of the support assembly and will "push" the floating bed forward, thus creating a known simulated thrust to compare with the value displayed on the indicator. This calibration unit is checked and certified by the National Bureau of Standards.

The thrust indicator unit can be energized by applying electrical power to the control room console and by switching ON the indicator. A thrust value of less than 100 lbs. will be exhibited on the indicator when the engine is in-operative. This "TARE" value was purposely applied to keep a known compressive force on the load cell at all times. The value should be recorded before and after engine testing and the average value should be used to compute the actual thrust.

There are two tie-down bolts on the left side of the engine support stand which MUST be loosened before operating the engine. A floating assembly is desired during engine operation, but the bolts should be tightened at all other times to protect the load cell from continual impact loads due to personnel working in the area.

6.4 Throttle Control & Position Indicator: This closed loop, constant pressure, hydraulic system consists of a hydraulic master control, a compensator, a vibration lock, a slave unit, a position transmitter and a position indicator.

Mounted on the control console is the master throttle control equipped with a control handle and a friction lock. The compensator is mounted inside the console while the slave unit and the vibration lock are mounted on the engine support assembly.

The system is serviced with hydraulic fluid through the compensator which keeps a constant pressure in the lines. The vibration lock prevents the system from drifting. an angular movement of the master throttle handle requires that the slave unit move an identical amount.

A remote electrical throttle position transmitter is mounted onto the slave throttle unit described above and indicates the angular position of the engine fuel control setting. This position is presented on the indicator adjacent to the master throttle on the console. When the slave unit is first linked to the engine control quadrant it will be necessary to "zero" the system to insure that the engine settings are identical with the data presented in the control room.

6.5 <u>Anti-icing Indication System</u>: The Control Switch for the engine anti-icing system is mounted on the individual plug-in panel provided for each engine. When the anti-ice system is not energized, the "Red" Anti-icing Indicator Light is illuminated. When the system is to be checked, the Control Switch should be "ON". If sufficient anti-icing pressure is available to the Anti-icing Pressure Switch mounted in the test chamber connector panel, the "Red" light will go OUT and the "Green" light will come ON. Always insure that the engine is stabilized in the range specified for these tests.

6.6 <u>Engine Connector Panel</u>: The instrumentation panel in the test chamber contains the outlets to all of the sensing lines and controls on the console in the control room. Quick-disconnect fittings are provided for attaching the hoses and lines from the test engine and its accessories.

Chemical separators are installed to deter any fuel or from entering the control console through the sensing lines in the case of engine malfunction. These units are mounted behind the connector panel and adjacent to the wall.

6.7 <u>Control Console</u>: The operator's console containes those control systems described above and also houses additional instrumentation necessary for exact engine performance analysis. These primary "monitoring" systems are described as follows;

The engine vibration indication system consists of four CEC Model No. 4-103 pickups, and a CEC Model No. 1-117 indicator. The pickups are mounted on brackets attached to designated sections of the engine. These locations are given the applicable NAVWEPS publications. It should be noted that

vibration filters are often required to remove extraneous frequencies that negate the data describing the operation of the engine component in question. These filters are installed in the rear panel of the indicator unit and should be checked for the appropriate filtering range before beginning engine operation.

The engine rotor speed indication system consists of a tachometer generators, pulse transducers, tachometer indicator and digital indicator.

Two "AN" type tach-generators and two pulse transducers are supplied to accommodate jet engines with two compressors, operating at different rotor speeds. The tach-generator and the pulse transducer are mounted in tandem on the engine accessary gear-box or on the compressor front case. The tachometers are connected to the "per cent" indicator in the control console. The signal from either tach-generator can be selected by a switch on the indicator.

The function of the pulse transducers is to provide a more accurate and more direct "RPM" indication of the two compressor rotors through the use of an electronic counter. Due to the time span required for this counting, the system will not accurately display changing rotor speeds. Thus it should be relied upon only during steady-state engine operation. To set the digital indicator it is necessary to determine the ratio of the engine rotor speed to the tach-generator RPM. This value should be set in the dials in the upper left-hand corner of the instrument.

Barometric pressure is indicated with a barometer mounted on the control console. A transfer valve enables this one instrument to be utilized for indicating the outside barometric pressure as well as the test chamber ambient pressure. A Barometric Pressure Light is illuminated when the gauge is indicating outside pressures. The light should go OUT when switching to the test cell pressures.

The compressor bleed valve pressures are monitored through the use of pressure switches in the test chamber connector panel and a selector switch mounted on the control console.

Pressure sensing lines from the compressor bleed valve duct are connected to the switches in the test chamber instrumentation panel. These

switches should be adjusted to translate pressures in the range expected for normal engine operation. During engine operation the selector switch should be rotated to all four positions. If the engine is operating normally in the "bleed valve range" the Bleed Valve Pressure Light should be illuminated at one of the positions. This then is the position that exhibits the actual outlet pressure of the bleed valve duct. This pressure should be checked with the limits in the applicabile NAVWEPS publication.

Two differential pressure gauges are installed in the console to reveal the test chamber pressure depression. The static pressure probes are located in the forward and at the rear of the cell. The values of pressure drop will vary with engine power setting, augmenter location and exhaust water flow rate. The differential pressure should never exceed 3.50 inches of H_2O.

All other pressure indications units are of the "bourden" tube type and require no further explanation.

Two temperature indication systems are available in the facility. The one unit is for low temperature ranges where iron-constantine thermocouples are utilized, while the other is for high temperatures and chromel-alumel probes. If the calibration of the thermocouple is not available it is recommended that the Jetcal Analyzer be used to verify the validity of the probes before engine operation. The Analyzer should be operated only by qualified technicians.

A Table of the complete instrumentation is included in Appendix I. In this data are presented the quantity measured, the manufacture's model number, the range of the instrument and the quaranteed accuracy.

7. Safety Hazards. The safe operation of the facility systems and the jet engine are based upon a sound knowledge of the operating procedures described above. However, characteristics peculiar to this type of test installation should be reviewed, the hazards should be understood, and the safety procedures should be obeyed.

7.1 Sound Levels: The sound levels from a gas turbine engine operating in an open environment are sufficient to cause physical damage to the

unprotected ear. Operation of the engine in an enclosed test facility compounds this danger due to the reverberating pressures within the chamber. Even if the ears are protected, internal bleeding can result from prolonged exposure. Therefore the following rules shall be enforced by the engine test director and the staff technicians:

NO personnel shall enter the engine test chamber when the engine is being operated above IDLE power.

NO personnel shall enter the test cell without adequate ear protection.

All personnel entering the chamber must be accompanied by a qualified staff technician.

7.2 Engine Starting: A thorough inspection of the rear exhaust passage and the test chamber shall be made by the test operator before starting the engine. After insuring that there are no personnel remaining in the cell the operator should close the rear double door, and exit through the front door to the control room.

After starting the engine, the operator will not accelerate above IDLE power for at least three (3) minutes, to insure that any persons remaining in the chamber can escape. When the engine is operated at high power settings the cell pressure depression is sufficient to make opening of any of the doors impossible.

7.3 Cardox Fire Protection System: The Cardox system is actuated by two switches on the control console. The Flood Switch when depressed will permit the entire supply of CO_2 to be released into the test chamber, while the Spurt Switch allows the operator to control the amount of CO_2 sprayed into the cell.

If an engine fire should develop the Spurt Switch should be depressed and held in this position until the fire is extinguished. Normally the entire supply of CO_2 should not be required, thus the use of the Spurt Switch insures that a reserve is available to combat any additional fires that may develop.

The test chamber should NOT be entered after energizing the Cardox system unless the personnel are equipped with portable breathing apparatus.

After insuring that the fire has been extinguished the chamber front doors should be opened for increased ventilation. However, personnel should not enter the test area for at least fifteen minutes.

7.4 Cooling Tower Water System: The water supply system has been described previously, however it should be emphasized that the cooling tower water pumps must always be operating when the compressors in the jet engine laboratory are in use. All personnel operating equipment in the Compressor Building which require the use of the cooling water should be alerted by the jet engine test operator that the pumps should not be turned OFF if the compressors in the jet engine laboratory are still operating.

8. Pre-start Procedure: In preparation for operating any engine in the enclosed test facility, the following sequences should be actuated as described in Section 2.

8.2 The Low Pressure Air Compressor, Air Heater and Supply System: Should be energized and adjusted concurrently at least thirty (30) minutes before the desired engine start time. The instructions in Sections 2. and the safety precautions in Section 7., should be rigorously followed.

8.3 The fuel system should be checked for proper operation by the procedures described in Section 3. Both fuel supply pumps should be activated and the supply pressure of each should be set at the same desired level.

8.4 The electrical power to the console and to the test chamber should be energized in accordance with Section 4.

8.5 The Cooling Water Supply System for the exhaust passage should be activated by the procedures in Section 5. Set the gate valve downstream of the pump at approximately 2/3 open. Actual operation of the water spray system is suggested before each day of testing, thus insuring that all valves are OPEN. The excess water will be evaporated during normal engine operation.

8.6 An inspection of the engine and the test chamber should be made by the engine operator and the test director. The chamber should be clear of foreign objects that may be ingested into the compressor inlet, and

all loose instrumentation should be securely fastened. The throttle linkage should be inspected as well as the starting air hose coupler, and the fuel supply hose.

The engine thrust stand restraining pins should be released which will unlock the flexure assembly for accurate thrust measurement.

CAUTION: Do NOT work on the engine when these pins are NOT tightened.

Inspect the compressor inlet for foreign objects and check the inlet instrumentation. Examine the engine exhaust area in similar manner.

Remove all personnel from the facility exhaust chamber and from the test cell area. The engine operator will close the rear door to the exhaust chamber and the door to the equipment room. The operator will then unlock the test chamber front double doors for emergency access and will exit through the front door to the control room.

8.7 The instrumentation on the control console should be adjusted as follows:

a. 28 VDC Master Switch--ON
b. 115 VAC Switch--ON
c. 120 VAC Switch--ON
d. Engine Master Switch--ON
e. Water Interlock Switch--ON
f. Ignition Cutout Switch--OFF
g. Starter Mode Selector--Low Press
h. Water Pump Switch--OFF
i. Bleed Air Selector--No. 1
j. Rotor Switch--N_2
k. Engine Temp. Switch (^oC)--Transient
l. Barometric Press. Switch--Test Cell
m. Fuel-to-Engine Switch--ON
n. Fuel Tank Pump Switch--Start
o. A/B Solenoid Switch--OFF
p. Anti-icing Valve Switch--OFF
q. A/B Motor Actuator Switch--OFF
r. Fuel Control Switch--Normal
s. High Temp. Selector (L/H)--Position No. 1
t. Low Temp. Selector (R/H)--Position No. 24

u. Beckman RPM Counter--ON
Time - 1 millisec, Slope - Positive, Function - E/UT, Attenuation - AC-1, PreSet - 2375/N_2 or 1473/N_1.

v. Vibration Indicator--ON
Channel - 4, Input - 2, Operation - Dx 1.0, Range - 5.

w. Fuel Flow Indicator--ON
Calibrate - "operate", Channel - Auto, Spec. Grav. - Auto.

x. Thrust Indicator--ON
Linearity - No adjustment, Operation Switch - Operate .

y. Throttle -- CUTOFF

9. Starting Procedure.

9.1 Depress the start Switch and monitor the per cent tachometer for N_2 speed. At 10% N_2 RPM actuate the Ignition Switch and OPEN the Throttle to the Idle setting, 33° to 35°.

An exhaust gas temperature rise will indicate a successful "light-off". The start temperatures normally do not exceed $800^{\circ}F$, thus any reading higher than this value indicates a possible malfunction and the throttle should be immediately retarded and the start aborted.

At 25% N_2 RPM release the Ignition Switch and the Starter Switch. Move the Starter Cutout Switch to OFF.

Check that the oil pressure is greater than 30 psi and that the fuel pressure is within 5 to 50 psig. Check the vibration levels of the four engine stations.

The engine can now be stabilized at Idle power, N_2 = 5636 - 25 RPM.

9.2 If the above limits cannot be realized or if the engine is to be shut down at the conclusion of the tests, the "engine shut-down sequence" is as follows:

After cooling the engine at Idle power for three minutes, advance the power to approximately 75% N_2 RPM for thirty seconds to clear the excess oil from the sumps and then retard the throttle to Cutoff.

Turn the following switches OFF immediately; Fuel-to-Engine Switch, Fuel Pump Switch and the Engine Master Switch. All other switches should be turned OFF when the control console is no longer in operation.

10. Operating Procedure.

10.1 All normal operation of the J-57-8B engine should be governed by the applicable NAVWEPS publication (NAVWEPS 02B-10ADC-503A). The test information, the operational adjustments and the limits are given in detail in Section 9-34, of this document. The NAVWEPS instructions are on file in the cabinet in the control room.

10.2 For convenience the thrust and TSFC variation with Compressor Inlet Temperature and Power Settings are presented in Appendix I. Also included is a table of the basic engine ratings, the Test Limits, and the estimated Thrust correction for use in performance calculations.

Quantity	Manufacture/Model	Range	Accuracy
Compressor Inlet Total Pr.	Merriam Manometer 0-80 In H_2O		NA
Compressor Inlet Static Pr.	Merriam Manometer	0-80 in H_2O	NA
Barometric Pressure	Wallace-Tiernan (FA139031)	28-31 In HgA	± .02 In HgA
Cell Static Pressure	Wallace-Tiernan (FA139031)	28-31 In HgA	± .02 In HgA
Low Compressor Disch. Total Pr.	Ashcroft (1245A)	0-100 PSI	± 1% FS
High Compressor Disch. Total Pr.	Ashcroft (1245A)	0-200 PSI	± 1% FS
High Compressor Disch. Static Pr.	Ashcroft (1245A)	0-200 PSI	± 1% FS
Burner Pressure	Ashcroft (1245A)	0-200 PSI	± 1% FS
Turbine Cooling Pressure	Ashcroft (1245A)	0-100 PSI	± 1% FS
Bleed Valve Pressure	Ashcroft (1245A)	0-200 PSI	± 1% FS
Turbine Disch. Total Pr.	Wallace-Tiernan (FA145640)	0-120 In HgA	± 0.1% FS
Fuel Supply Pressure	Ashcroft (1245A)	0- 60 PSI	± 2% FS
Engine Fuel Pump Pressure	Ashcroft (1245A)	0-1000 PSI	± 2% FS
Oil Pump Pressure	Ashcroft (1245A)	0-100 PSI	± 2% FS
Scavenge Oil Pressure	Ashcroft (1245A)	0-100 PSI	± 2% FS
Test Chamber Depression	Wallace-Tiernan (FA141500)	0-10 In H_2O	NA
Compressor Inlet ΔP	Wallace-Tiernan (FA1411500)	0-115 In H_2O	NA
Bleed Valve Sense Pressure	Ashcroft (1245A)	0-60 PSI	± 1% FS
Bearing Vent Pressure	Ashcroft (1245A)	0-60 PSI	± 1% FS
Ambient Temperature	Brown Recorder (IC T/C)	0-800°F	± .25% FS
Cell Temperature	Brown Recorder (IC T/C)	0-800°F	± .25% FS
Compressor Inlet Temp.	Brown Recorder (IC T/C)	0-800°F	± .25% FS
Low Compressor Disch. Temp.	Brown Recorder (IC T/C)	0-800°F	± .25% FS
High Compressor Disch, Temp.	Brown Recorder (CA T/C)	0-2400°F	± .25% FS
Exhaust Gas Temp. (4 probes)	Brown Recorder (CA T/C)	0-2400°F	± .25% FS
Fuel Flow	GE-9849338	0-100000 PPH	± .50% FS
Exhaust Gas Temp. ("C" gauge)	Lewis Gauge 17B545B	0-1000°C	± .20% FS
Fuel Density	GE-9849338	.60-.90	± .001
Thrust	GE-9849320	0-300000 Lbs	± .50% FS
Low Rotor Spped-RPM	Berkeley-8151R	25-42000 RPM	± .0001
Low Rotor Speed-%	GE-8DJ82CAA-1	0-110%	± .50% FS
High Rotor Speed-RPM	Berkeley-8151R	25-42000 RPM	± .0001
High Rotor Speed-%	GE-8DJ82CAA-1	0-110%	± .50% FS
Vibration (4 positions)	CEC(1-117)-Pickups(4-103)	-------	± NA
Timer	Std. Electric (SM60-3H)	0-60 Hr.	± NA
Throttle Position Ind.	GE-2JR191	0-120°	± 1°

FS - Full Scale, NA - Not Available, IC - Iron/Constantine T/C, CA - Chromel/Alumel T/C

TABLE OF RATINGS

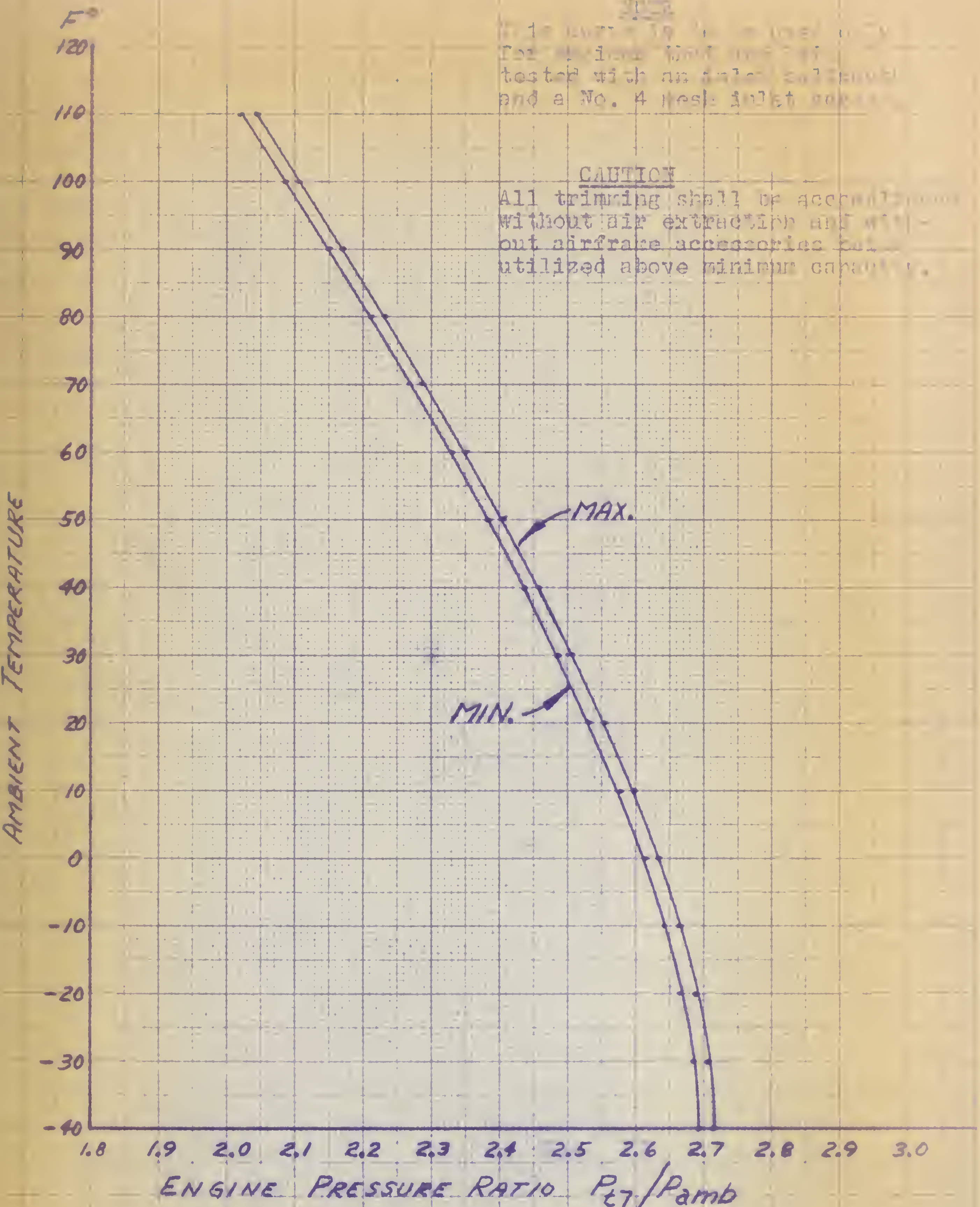
Power	Thrust Lbs.	N_1 RPM	N_2 RPM	TSFC PPH/LB	EGT °F
Max A/B	16000 Lbs	6100 Max	9800 Max	2.10	1140 Max
Military	10200	6100 Max	9800 Max	.835	1120 Max
Normal	8700	5780 Max	9550 Max	.815	1050 Max
Cruise	6500	5310 Max	9120 Max	.800	1050 Max
Idle	600 Max	2200 Max	6250 Max	1.90	644 Max
Starting	----	----	5635 - 25	----	1100 Max
Acceleration	----	----	----	----	1200 Max

Oil Pressure Limits: 30 PSI at Idle, 45-50 PSI all other powers

Fuel Pressure Limits: 5-50 PSIG

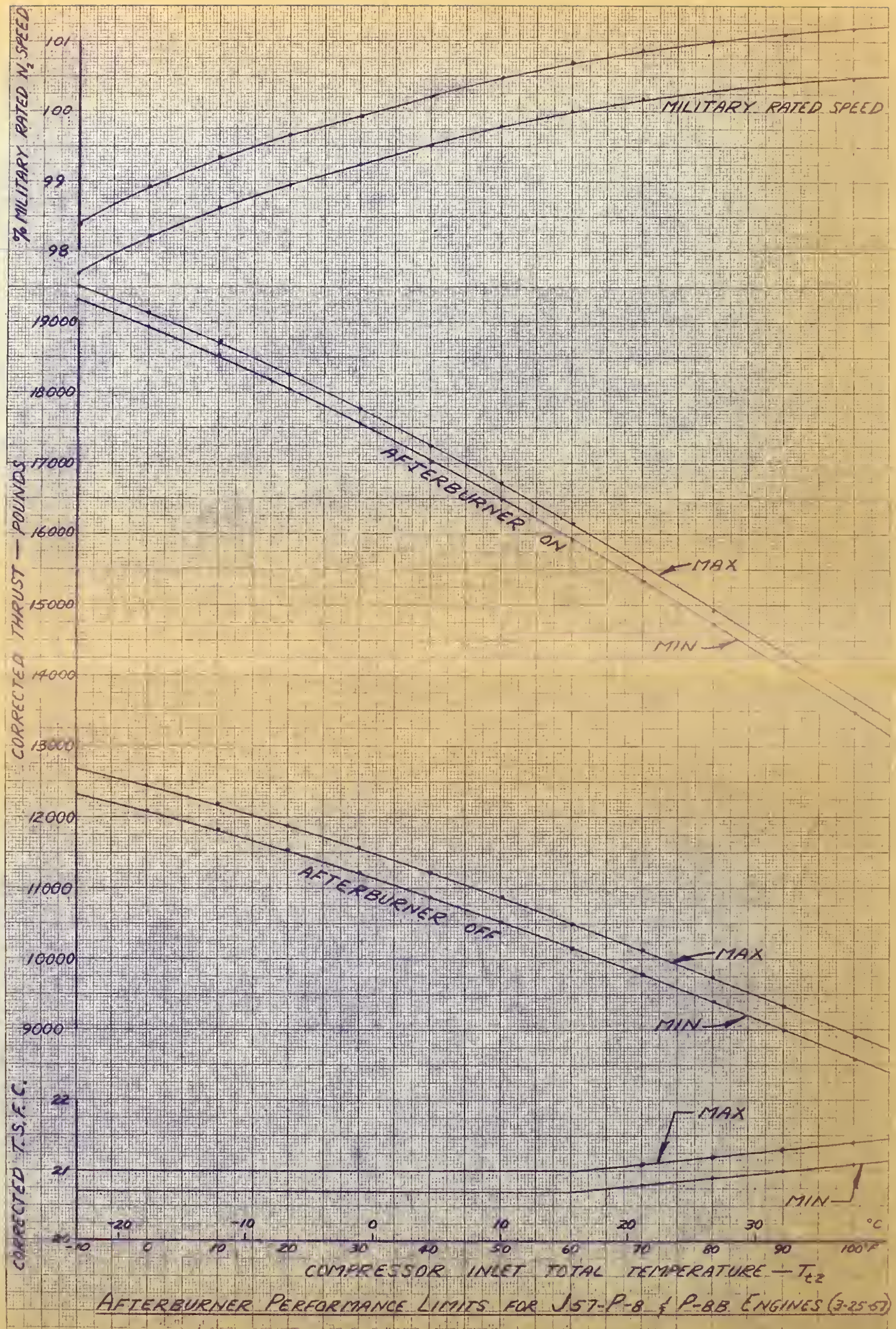
Oil Consumption: 3.5 pints per hour

Oil Temperature Range: 215°F to 248°F



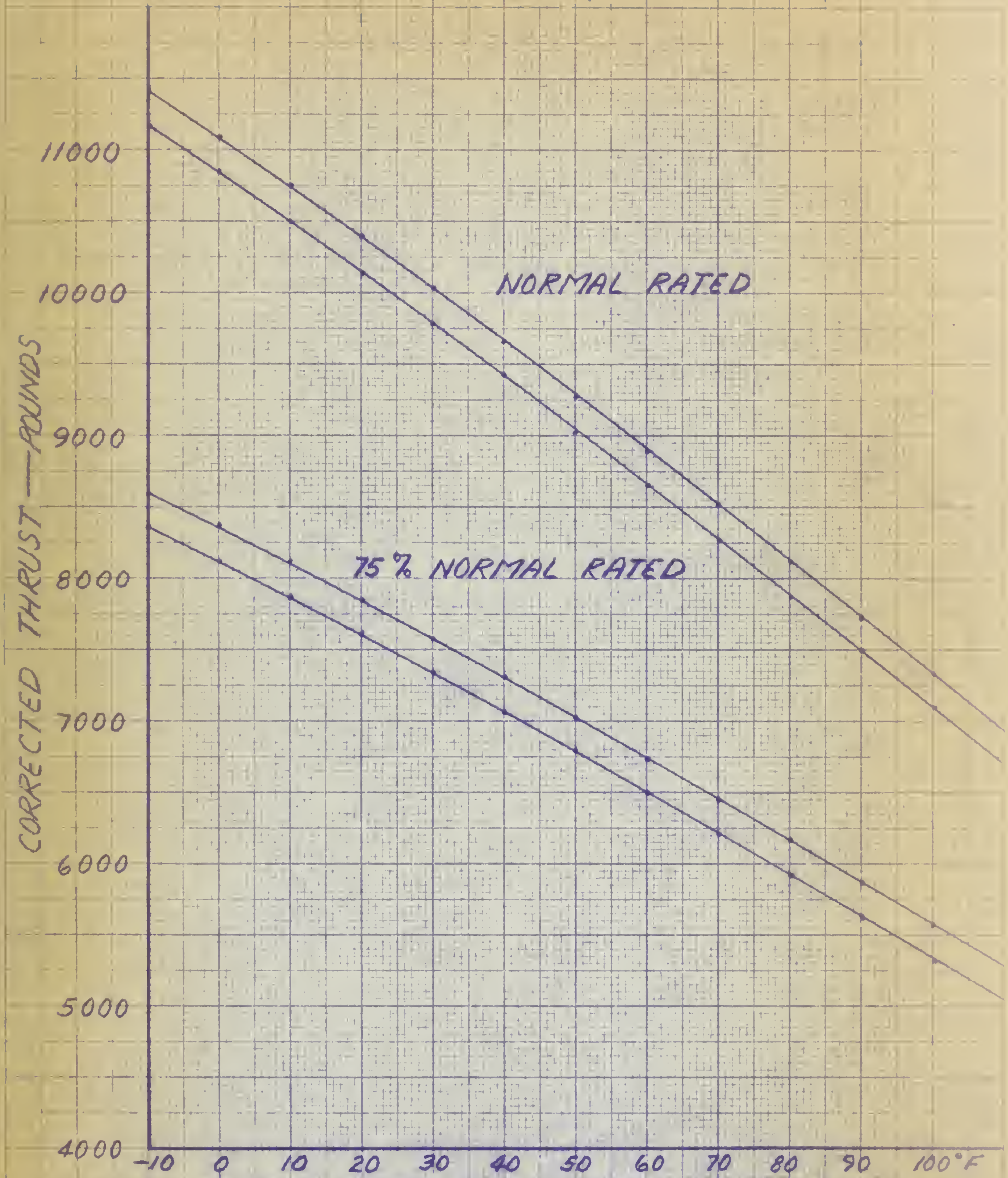
MILITARY RATING FUEL CONTROL TRIM CURVE
FOR J57-P-8 & P-88 ENGINES (9-15-58)

4-16-64 RAB



AFTERBURNER PERFORMANCE LIMITS FOR J57-P-8 & P-8B ENGINES (3-25-57)

4-16-64 RAB



NORMAL RATED & 75% NORMAL RATED THRUST CURVE FOR J57-P-8, P-8A, & P-8B ENGINES (11-5-58)

4-16-64 RAB

USNPGS TEST CELL THRUST CORRECTION VS.
J-57-8B ENGINE POWER
(APPROXIMATE)*